VARIATIONS IN THE FELL-AND-BURN SYSTEM TO REGENERATE PINE-HARDWOOD MIXTURES IN THE PIEDMONT[1]

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Abstract—Several variations of the fell-and-burn system were tested in the Piedmont region. Results indicate that this system can successfully improve the value of low-quality hardwood stands by introducing a pine component. After four growing seasons, fell-and-burn treated stands, on poor- to medium-quality sites, were dominated by oaks and pines of nearly equal height. The precise timing of felling residual stems, as prescribed by the fell-and-burn system, may be unnecessary because winter and spring felling produced similar results. Site preparation burning may be necessary to ensure pine survival. These burns controlled hardwood height growth, allowing planted pines to become as tall as hardwoods by the end of four growing seasons. Hardwoods in unburned treatment areas remained taller than pines and could suppress pine growth and survival in future growing seasons.

INTRODUCTION

Approximately 80 percent of the forested land of the southeast Piedmont is owned by individuals or family groups. These nonindustrial private forests (NIPF) are small (average about 10 acres) and most are cutover lands or old abandoned farms. In most instances, the timber is low quality and grows in unmanaged pine-hardwood or hardwood stands (McMinn 1983). Demand for timber from the Piedmont region is increasing because of coastal timber losses from Hurricanes Hugo and Andrew and public demands to use National Forests for nontimber objectives. To meet these increasing demands, improved productivity on NIPF lands in the Piedmont has become a major goal.

Although NIPF landowners are not primarily interested in timber production, they are attracted to enhancing their income as long as their forest lands can provide other benefits. The ability to establish pine-hardwood mixtures for multiple uses would offer these landowners an alternative to expensive pine plantations established primarily for timber production.

An inexpensive regeneration system, which may be used as an alternative to pine monoculture, is the fell-and-burn technique (Abercrombie and Sims 1986). This technique has been successful for converting low-quality hardwood stands to more productive pine-hardwood mixtures in the Southern Appalachian Mountains (Phillips and Abercrombie 1987). Complete descriptions of the fell-and-burn technique are given by Phillips and Abercrombie (1987) and Waldrop and others (1989). Briefly, the technique involves a commercial clearcut followed by a spring felling of residual hardwood stems (> 5 feet in height) and a summer broadcast burn. These treatments are designed to control hardwood sprout growth so pines can be established without eliminating hardwoods. Pines are planted the following winter at a wide spacing (10 by 10 feet or more) to allow some hardwood dominance in the stand.

Several aspects of the fell-and burn technique need further study. It is anticipated that this technique will produce results in the upper southeastern Piedmont similar to those observed in the mountains. However, differences in climate, soils, topography, and rainfall may necessitate refinements to the technique (Waldrop and others 1989). The short time periods for felling (May to June) and burning (mid-July to August) are major limitations of this technique. Felling at different times of the year or eliminating burning may resolve these limitations and problems. However, these variations of the fell-and-burn technique have not been tested.

This project represents the first attempt to study the fell-and-burn system on Piedmont sites. It examines the effects of the fell-and-burn system and three variations of that system on stand development through four post-harvest growing seasons.

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METHODS

Study sites are located on the Clemson University Experimental Forest in Pickens and Anderson Counties of South Carolina. These sites were chosen because they are similar in aspect, soil, and vegetation. All sites were classified as subxeric to xeric (Jones 1989) and occurred on south-facing slopes. Before harvesting in December 1987 and March 1988, major tree species included white oak (*Quercus alba* L.), southern red oak (*Q. falcata* Michaux.), post oak (*Q. stellata* Wangenh.), black oak (*Q. velutina* Lam.), scarlet oak (*Q. coccinea* Muenchh.) chestnut oak (*Q. prinus* L.), hickory (*Carya* sp.), and shortleaf pine (*Pinus echinata* Miller). Minor tree species included blackgum (*Nyssa sylvatica* Marshall), sourwood (*Oxydendron arboreum* (L.) DC.), dogwood (*Cornus florida* L.) and yellow-poplar (*Liriodendron tulipifera* L.). Slopes averaged 7 to 10 percent on all replications. All soils were described as Typic Hapludults.

Before harvest, 87 plots, 1/10th acre in size, were established in three replications of four treatments. The treatments included: 1) spring felling of residuals with summer broadcast burning (the fell-and-burn technique), 2) winter felling of residuals with summer broadcast burning, 3) spring felling of residuals with no burning, and 4) winter felling of residuals with no burning.

Phillips and Abercrombie (1987) suggested that sprout vigor would be reduced by felling residual hardwood stems in spring when carbohydrate reserves in root systems are typically low. Winter felling and spring felling were compared to determine if sprout height growth was reduced by spring felling. Chainsaw crews felled all residual stems over 5 feet tall. Winter felling was completed in early March 1988; spring felling was completed in June 1988.

Burning occurred on July 7, 1988, two days after a rainfall of 1/2 inch. Humidity at the time of burning was 50-60 percent, and wind speed was approximately 5 mph. Moisture content of 10-hour timelag fuels (0.25-1 inch in diameter) was 12 percent at 10:00 A.M. and 9 to 10 percent after noon. Backing fires were started along the edges of the units until a sufficient blackened strip was attained. Strip-head fires were used to ignite the interior fuels.

Improved loblolly pine seedlings were hand planted by contract crews in all treatment areas during March 1989. Observations on the Sumter National Forest and the results of a previous study in the Piedmont (Nix and others 1989) indicated that pines outcompete and overtop hardwoods on fell-and-burn sites in 7 to 10 years. To reduce costs and allow favorable conditions for hardwood development, pines were planted at spacings of 15 by 15 feet (194 seedlings per acre) in this study.

In each treatment area, five to eight sample plots were established; each was 1 chain by 1 chain square (1/10 acre). Plot centers were generally 80 feet apart (leaving a 14-foot buffer between plot boundaries), but this distance varied by topography. Prior to harvest, the species, dbh, and height of each tree was recorded. Advance regeneration was tallied by species and origin (seedling or sprout). After harvest, regeneration data were collected at the end of the fourth growing season (1991). Measurements on hardwoods included: 1) number of seedlings and sprouts by species, 2) sprouts per stump, and 3) height of the dominant sprout on each stump. Treatment differences were compared with each variable for the common species or species groups including: oak, hickory, blackgum, other hardwoods, and all species combined. Survival and height of planted pines were measured for a 100-percent sample of each 2-acre treatment area.

RESULTS AND DISCUSSION

Broadcast burns were high-intensity with flames reaching heights of 10 to 15 feet where fuel loading was heavy. Fire behavior appeared to be affected by the season of felling. In winter-felled areas, limited loading of fine fuels produced fires that did not carry between slash piles. In spring-felled areas, dry leaves served as fuels to carry the fire. Spring felling tended to produce uniform burns across the entire study area, while winter felling produced a patchy burn pattern.

At the end of four growing seasons (1991), species composition was similar to preharvest stands and was largely unaffected by site preparation treatments. No significant differences between treatments occurred in the number of stems per acre for blackgum and pines (table 1). The total number of stems per acre ranged from 9,208 to 12,636. Burning significantly increased the number of stems per acre of hickories and other hardwoods.

The number of oak stems appeared to be significantly reduced by burning (table 1). Burned areas averaged less than 3,500 oak stems per acre, while unburned plots had over 5,000 oaks per acre. However, this

Table 1–Species composition of regeneration at the end of the 1991 growing season (four seasons after harvest)

Treatment	Oaks[1]	Hickory	Blackgum	Other Hardwoods	Pines	Total
	Stems per acre					
Winter fell/no burn	5095 b[2]	904a	543a	4383a	297a	11,222a
Spring fell/no burn	4991 b	710a	178a	3005a	324a	9,208a
Winter fell/burn	2924a	1397 b	136a	6064 b	516a	11,037a
Spring fell/burn	4047ab	1615 b	649a	5910 b	415a	12,636a

[1] Scarlet oak, southern red oak, white oak, post oak, black oak, chestnut oak.
[2] Means followed by the same letter within a column are not significantly different at the 0.05 level.

difference may be due to plot location rather than fire effects because burning tended to increase the number of sprouts per stump rather than decrease them (table 2). This effect was significant for the oak and all species groups. In addition, site preparation burning had no effect on the percentage of stumps that produced sprouts through the first four growing seasons (table 3).

By the end of four growing seasons, the dominant sprout in each clump averaged over 5 feet tall for all treatments (table 4). Sprouts in burned treatment areas were significantly shorter than in unburned areas for all species and groups. Sprouts which emerged the spring following harvest were top-killed by burning. New sprouts which emerged after burning had a shorter growing season and, therefore, less height growth than sprouts in unburned areas. Additional control of hardwood growth, which was thought to be provided by spring felling, was evident only in the other hardwood group. In this group, stems in unburned areas felled in spring were significantly shorter than those in unburned areas felled in winter.

Table 2–Mean number of sprouts produced by each stump by species and treatment at the end of the 1991 growing season (four growing seasons after harvest)

Treatment	Oaks[1]	Hickory	Blackgum	Other Hardwoods	All Species
Winter fell/no burn	4.6a[2]	3.5	2.8	6.0a	5.0a
Spring fell/no burn	4.8a	4.0	2.0	6.2a	4.9a
Winter fell/burn	5.9 b	3.5	4.6	8.3 b	6.5 b
Spring fell/burn	6.2 b	4.4	3.3	6.7a	6.0 b

[1] Scarlet oak, southern red oak, white oak, post oak, black oak, chestnut oak.
[2] Means followed by the same letter within a column are not significantly different at the 0.05 level.

Table 3--Percentage of stumps that survived and produced sprouts through the 1991 growing season (four growing seasons after harvest)

Treatment	Oaks[1]	Hickory	Blackgum	Other hardwoods
Winter fell/no burn	91.0	81.8	70.8	93.1
Spring fell/no burn	89.1	68.0	63.9	90.1
Winter fell/burn	88.9	90.4	57.9	96.6
Spring fell/burn	82.5	76.5	75.0	94.1

[1] Scarlet oak, southern red oak, white oak, post oak, black oak, chestnut oak.

Table 4-- Average height (feet) of the dominant sprout by species group and treatment at the end of the 1991 growing season (four growing seasons after harvest)

Treatment	Oaks[1]	Hickory	Blackgum	Other hardwoods	All species
Winter fell/no burn	11.0a[2]	6.9a	8.3a	11.0a	10.4a
Spring fell/no burn	11.2a	6.7a	7.2a	10.0 b	9.9a
Winter fell/burn	8.3 b	4.8 b	4.2 b	8.4 c	7.5 b
Spring fell/burn	8.7 b	4.0 b	3.5 b	8.2 c	7.6 b

[1] Scarlet oak, southern red oak, white oak, post oak, black oak, chestnut oak.
[2] Means followed by the same letter within a column are not significantly different at the 0.05 level.

Controlling hardwood height growth by burning may prove beneficial to the growth and survival of planted pines. In the Autumn of 1991, planted pines had grown for three growing seasons, while hardwoods had grown for all (unburned) or a portion (burned) of four growing seasons. Pines were nearly as tall as hardwoods in burned areas but remained shorter than hardwoods in unburned areas. Pine heights ranged from 7 to 8 feet (table 5), but heights were not significantly different between treatments. Mean height of hardwoods was 7.5 feet in burned areas but over 10 feet in unburned areas (table 4).

Survival of planted pines was good, averaging approximately 65 percent (126 stems per acre) for all site preparation treatments (table 5). Most of the pines that survived through 1991 appeared healthy and may become a major component of the regenerated stand.

In all treatment areas, hardwood crowns had not over the pines, therefore, most pines were free to As crowns close, however, hardwoods may over pines in unburned areas and pine mortality may increase.

CONCLUSIONS

This study indicates that the fell-and-burn system be successfully used in the Piedmont region to establish a mixed stand of pines and hardwoods. Burning in July controlled hardwood sprout grow reducing the length of the growing season. This remained apparent through four growing season Almost 65 percent of planted loblolly pines (126 acre) survived throughout the study period. Mos these pines had caught up with the hardwoods a become a dominant component of the future sta Oaks, which were taller and more numerous tha

Table 5–Survival and height of planted loblolly pine seedlings after the 1991 growing season (three growing seasons after planting)

Treatment	Percent Survival	Height (ft)
Winter fell/no burn	69.0	7.8
Spring fell/no burn	67.7	7.6
Winter fell/burn	68.6	7.4
Spring fell/burn	58.3	7.0

hardwood species will probably become a codominant species in the stand.

This study also indicates that some variations of the fell-and-burn technique may be used successfully. Winter felling of residual stems, followed by summer burning produced nearly identical stands to those regenerated by the fell-and-burn treatment (spring felling and summer burning). Winter felling did not control hardwood growth as well as spring felling. However, growth reductions from spring felling had no apparent effect on stand development. This result indicates that the precise timing of felling as prescribed by the fell-and-burn system may be unnecessary in some cases.

Successful establishment of pine-hardwood mixtures may be possible without site-preparation burning. However, these stands are too young to completely evaluate the success of planted pines. Through the 1991 growing season, pine survival and growth in unburned plots equalled that of burned plots, indicating that burning may not be necessary. However, pines in unburned plots remained 2 to 3 feet shorter than hardwoods after four growing seasons. If pines continue to grow rapidly in unburned areas, they should overtop hardwoods and become a dominant component of the stand. However, hardwood crowns might close first and pines would become suppressed. Stand development in all treatment areas will be measured for several years to determine the need for site preparation burning.

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